CASE STUDY – BENCH SCALE BIODEGRADATION OF CHLORINATE SOLVENTS – TCE/TCA

THE PROBLEM

Chlorinated solvents, such as trichloroethylene (TCE) and trichloroethane (TCA), are the most commonly *reported* contaminants at Superfund Sites. According to EPA's Toxic Chemical Release Inventory, TCE releases to land and water totaled over 30,000 lbs in the period from 1987 to 1993.

METHODOLOGY

Nordevco Associates contracted the W. M. Ward Technical Service Laboratory (at the time,the Province of Manitoba Department of Environment lab) to conduct an evaluation of the ability of its BactiDomus® y Technology to effectively biodegrade trichloroethane and trichloroethylene in a bioreactor constructed by the lab to Nordevco specifications.

The bioreactor was a gravity fed sealed unit constructed of polyvinyl chloride. For the initial test, the total reactor volume was *14* liters. The system consisted of two tanks, an upper gravity feed storage tank (18 liters) and the bioreactor tank (14 liters). For the second test, a second 14-liter in series bioreactor tank was added to the system to double the contact time between contaminants and the BactiDomus® Technology product. Flows were regulated by integrated controls. Reactor airflow was individually controlled with an activated carbon capture venting system.

THE TECHNOLOGY

Nordevco's BactiDomus® Technology was developed by a diversified group of research scientists working together at Universities in Belgium and France. Their goal was to create a mechanism with the flexibility to delivery biological solutions to a range of environmental issues more effectively and efficiently

The foundation for the success of the BactiDomus® Technology was the development team's clear understands that for any carrier material to be successful it had to meet specific underlying needs of the organisms:

- Regardless of the organisms used, they would be cultured in a sterile laboratory and would require time to acclimate to the environment they were activated in.
- Microorganisms, like humans, do not exist or thrive in isolation of each other but rather rely on others for stimulation and competition;
- Organisms prefer to grow and live in colonies or flocs and prefer to attach to something to anchor these colonies;
- Individual species of microorganisms do not work in isolation to break down organic compounds. To successfully break down any organic completely to CO2 and H20, a variety of different organisms are required;

The result of that work is the BactiDomus® Technology which is based on the use of an inorganic limestone-like porous carrier material. The porosity of the material allows it to be bathed in a nutrient broth, absorbing key micro-nutrients that act as an initial food source when the product is activated.

It is then impregnated with a range of different naturally occurring and non-pathogenic organisms, selected for their ability to breakdown specific organic contaminants.

The organisms selected for inclusion are selected based on the understanding that each contaminated environment can be aerobic, anaerobic or facultative anaerobic. Therefore, aerobic, anoxic and anaerobic organisms are selected and used in each product to ensure that they can function successfully in a broad range of environments.

The carrier material's large surface area to size ratio provides the organisms with both internal and external floc points where they grow and create large effective colonies of biodegraders working together to break down the organic contaminant into carbon dioxide and water.
The carrier material's hydrophilic nature allows it to absorb both the water and contamination. This provides a steady strong contact between the imbedded organisms and organic contaminant. This ensures that the organisms have a continuous food source as they grow and create flocs within the protective confines of the capillary network of the carrier material.

THE RESULTS

A preliminary biodegradation study verified that there was no chemical breakdown of the TCA or TCE over a 36-hour period without the addition of BactiDomus(R) Technology products. At the conclusion of the test, the BactiDomus(R) Technology products and sediment slurry (inorganic carrier material residue that collected in the bottom of the bioreactor(s)) were analysed for TCA and TCE and non detectible values were laboratory reported. The chloride content of the BactiDomus(R) Technology products was 0.01%. The chloride content for the sediment slurry was 676 mg/l.

The dual chamber bioreactor test indicates that increasing the contact time between contaminant and Delivery modules increases the rates of treatment. The results of the dual chamber bioreactor priming suggest that the BactiDomus®™ Technology would be very effective in a closed loop batch treatment environment for the treatment of both TCA and TCE

Quoting from the labs report:

1. The Nordevco BactiDomus® Technology's microbial biodegradation process can effectively biodegrade trichloroethane and trichloroethylene;
2. There was no loss of trichloroethane and trichloroethylene to the atmosphere;
3. There was no absorption of trichloroethane and trichloroethylene onto the BactiDomus(R) Technology products and sediment;
4. There was no chemical breakdown of trichloroethane and trichloroethylene over the 36 hour period without microbial degradation.

	Single chamber bioreactor				Dual chamber bioreactor			
	TCA ug/l	% Reduction	TCE ug/l	% Reduction	TCA ug/l	% Reduction	TCE ug/l	% Reduction
Bioreactor Priming[1]								
Initial Concentration	**10,300**		**8,270**		**20,000**		**22,000**	
48 Hours	**5,900**	**42.7%**	**4,200**	**49.2%**	**90**	**99.6%**	**280**	**98.7%**
Full Activation[2] **(Treatment)**								
Initial Concentration	**8,656**[3]		**6,776**[3]		**10,000**[3]		**9,800**[3]	
23 Hours	**670**	**92.3%**	**910**	**86.6%**	N/a	N/a	N/a	N/a
24 Hours	N/a	N/a	N/a	N/a	**480**	**95.2%**	**870**	**91.1%**
49 Hours	N/a	N/a	N/a	N/a	**55**		**160**	
96 Hours	N/a	N/a	N/a	N/a	**13**	**99.9%**	**29**	**99.7%**
97 Hours	**34.2**	**99.6%**	**98.2**	**98.9%**	N/a	N/a	N/a	N/a
118 Hours	N/a	N/a	N/a	N/a	**8.1**	**99.9%**	**18**	**99.8%**
145 Hours	**9.5**	**99.9%**	**23.1**	**99.7%**	N/a	N/a	N/a	N/a

1. Bioreactor priming refers to the initial period of bioreactor operation when contaminated water is recycled through the bioreactor tank to ensure the proper operation of the tank and to acclimate the delivery module to the contaminant. When acclimation is completed, the valve controlling the flow of water from the storage tank to the bioreactor is closed and contaminated water in the upper storage tank is isolated from the bioreactor tank. In the case of the second dual chamber bioreactor test, water is recycled through the two-bioreactor tanks to ensure their proper operation and to acclimate the delivery modules in the two-bioreactor tanks. In an on-site pump and treat application, the bioreactor priming would refer to the pre-treatment phase where systems are run to ensure proper operation and the integrity of all connections and valves. This process was also designed to model a closed loop pump and treat system.
2. Full activation refers to the process of introducing air to the reactor and opening the valve that isolates the upper storage tank from the lower bioreactor tank(s), and allowing the total volume of water (32 liters in the single bioreactor tank test and 46 liters in the dual bioreactor chamber test) to recirculate through the system. In an on-site pump and treat situation, full activation would refer to commencing active biotreatment.
3. The increase of the TCA/TCE concentration (commencing treatment) resulted from introducing the contents of the storage tank (feed valve open) into the bioreactor tank(s). The storage tank contained water spiked with TCA/TCE at approximately the same concentration as the initial reading. This higher concentration increased the concentration in the bioreactor(s).

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